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COMPARATIVE STUDY OF CO_2 ADSORPTION USING DIFFERENT TYPES OF FLY ASH

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ABSTRACT

In present work, thermal power plant ash and sugar cane bagasse fly ash were used as an adsorbent for CO_2 adsorption on continuous basis. Maximum adsorption capacity of the thermal power plant ash and sugar cane bagasse fly ash were found to be 13.39 mmol/g, 33.48 mmol/g, respectively at flow rate of 75 mL/min. at atmospheric pressure and temperature.

Key words: Adsorption, Carbon dioxide, Thermal power plant fly ash, Bagasse fly ash.

INTRODUCTION

The world's dependence on fossil fuels for the satisfaction of primary energy needs is at odds with growing atmospheric emissions of CO_2 from the combustion of hydrocarbons. More than 85% of the world's commercial energy needs are met by burning fossil fuels, including coal, oil and gas. Power stations burning fossil fuels account for a large percentage of CO_2 emission[1,2]. Among the various capture approaches, absorption, membranes, cryogenic, adsorption and others, CO_2 capture by pressure/vacuum swing adsorption. In terms of achieving high adsorption capacities, activated carbons (ACs) and zeolite-based molecular sieves have shown much promise. ACs generally gives higher additional capacity at different flow rates compared to zeolites. CO_2 adsorption capacities of activated carbons depend on their pore structure but also on the surface chemistry properties to investigate the relevant studies on carbon fibre composite adsorbent for CO_2 capture and discuss fabrication parameter of the adsorbent and their CO_2 adsorption in detail[3]. The most important separation of CO_2 from flue gas presents several technical challenges. First, the two major

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components in flue gas (CO_2 and N_2) are very similar in molecular size. It is difficult to separate them based on the most common size sieving separation principles[4]. The performance of granular activated in effectively adsorbing volatile organic compounds from inert gaseous stream under varying operating condition. Experiments were carried out to study adsorption of toluene a volatile organic compound in a fixed bed adsorption column under various operating conditions[5,6]. The effectiveness of using pecan and almond shell-based granular activated carbon in the adsorption of volatile organic compounds of health concern known toxic compounds compared to the adsorption efficiency of commercially used carbon in simulated test medium[7]. Chue et al.[8] compared zeolite 13X and activated carbon by studying the effects of feed rate and purge gas quantity and claimed that 13X performed better in PSA/VSA CO_2capture processes. Park et al.[9] used numerical analysis to get the optimum purge/feed ratio in terms of lower power consumption and also confirmed the significance of a pressure equalization step, which would improve the product purity without requiring extra power. In 1992, many studies (bench scale, pilot and demonstration scale) have been conducted worldwide in the field of CO_2 capture by adsorption, especially in Japan and Korea. The Japanese power industry started investigating flue gas CO_2 capture with pilot plants using physical adsorption at their power stations in the early 1990s[10]. One of the main issues is the concentration measurement of VOC in a gas-vapor mixture. Das et al.[6] assumed gas to be saturated after being passed through the column filled with the VOC liquid. Some researchers[11] also assumed the exit gas to be saturated with VOC at the concentration corresponding to the temperature of the bubbler. Hoa et al.[12] estimates the cost of CO_2 capture for three Australian industrial emission sources: iron and steel production, oil refineries and cement manufacturing. It also compares the estimated capture costs with those of post-combustion capture from a pulverized black coal power plant.

In present work, we used fly ash from thermal power plant and bagasse fly ash as an adsorbent to minimize air pollution and find out the maximum breakthrough adsorption capacity of both the adsorbent at different flow rates.

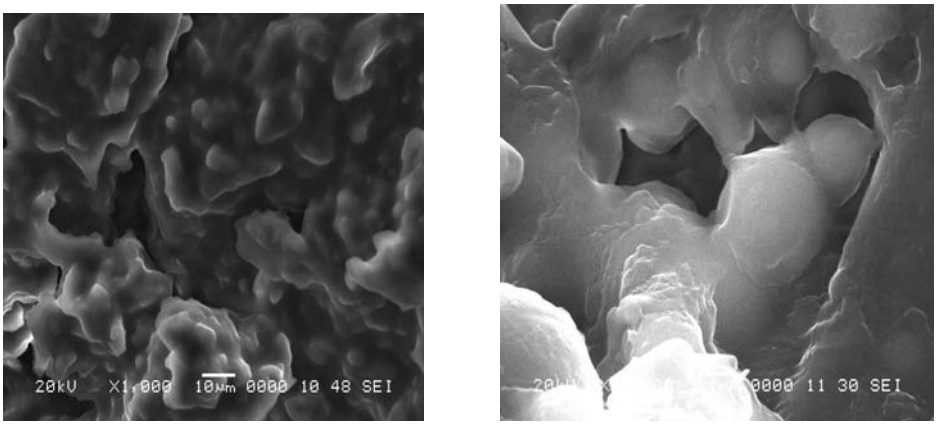
EXPERIMENTAL

Adsorption studies were carried out by using packed bed reactor. Gas cylinder consist of 20% CO_2 and 80% He as inert. Specifications of packed bed reactor were 19.2 cm length and 1.6 cm diameter. The weighed amount of adsorbent was placed into the adsorption column and is supported by glass wool from both sides to avoid any carryover adsorbent particles. Maintaining the constant flow rate of gas was passed to the adsorption

column. Time required for the saturation of bed for thermal power plant fly ash and bagasse fly ash are five and half and five hour respectively. At outlet gas was collected in the balloon. Balloons were purged before taking sample to avoid any contamination. Sample was collected at equal interval of time. Analysis of the samples was done by Orsat Apparatus. The same procedure was carried out by different flow rate for different adsorbent.

Characterization

Screening electron microscope analysis



(a) **(b)**

Fig 1: SEM images of (a) thermal power plant fly ash; (b) bagasse fly ash

In Fig. 1 SEM (Screening electron microscope) images sample (a) shows very compact and uniform structure however sample (b) shows very porous agglomerate structure like iceberg, providing communication between adjacent pores and a large inter-particle void volume. This is important for smooth passage of gas molecules through the voids.

Fourier transforms infrared spectrogram analysis

Fig. 2 shows that FTIR spectrum of thermal power plant fly ash and CO2 adsorbed thermal power plant fly ash FTIR study of thermal power plant fly ash; which show the presence of functional group –OH (1335 cm^{-1}), C = O (1793 cm^{-1}), C = C (2132, 2236 cm^{-1}), >C = O (1022, 1106 cm^{-1}), = CH_2 (2850 cm^{-1}). In case of CO_2 adsorbed thermal power plant ash, additional peaks was noticed at carboxylic group 1210 cm^{-1}, which corresponding to the medium strectching of CO_2 molecule.

Fig. 3 shows that FTIR spectrum of bagasse fly ash and CO_2 adsorbed bagasse fly ash. In FTIR study functional group presence in bagasse fly ash were C-H deformation

assigned to asymmetric stretching (600-700 cm^{-1}), $=CH_2$ (834, 898 cm^{-1}), N-H (3425, 3423 cm^{-1}). In CO_2 adsorbed bagasse fly ash observed additional peaks at C ≡ C (2140 cm^{-1}) symmetry reduces intensity, C-H (898 cm^{-1}) medium asymmetric stretching.

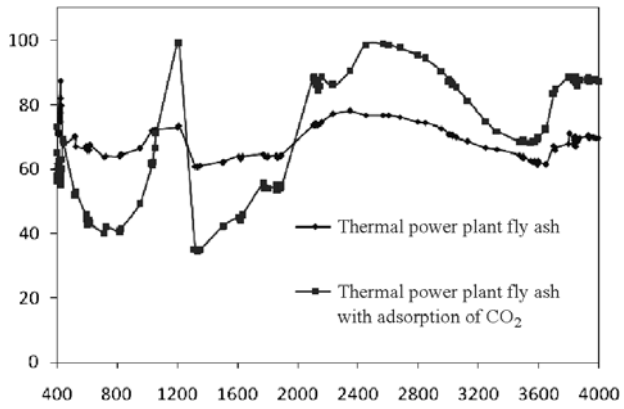


Fig. 2: FTIR spectra of thermal power plant fly ash and CO_2 adsorbed thermal power plant fly ash

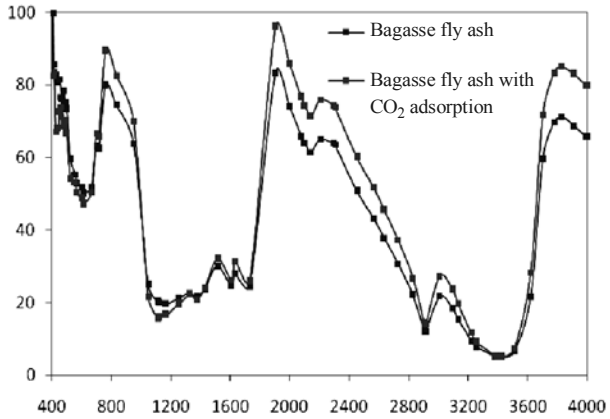


Fig. 3: FTIR spectra of bagasse fly ash and CO_2 adsorbed bagasse fly ash

RESULTS AND DISCUSSION

A range of different flow rates was used to estimate appropriate adsorption step times during break through experiments at atmospheric pressure and temperature. The gas concentration was 20% CO_2 in all breakthrough experiments. A representative set of data are shown in the breakthrough curves in Figs. 3 and 4. It is seen that the breakthrough time is shortened when flow rates are increased.

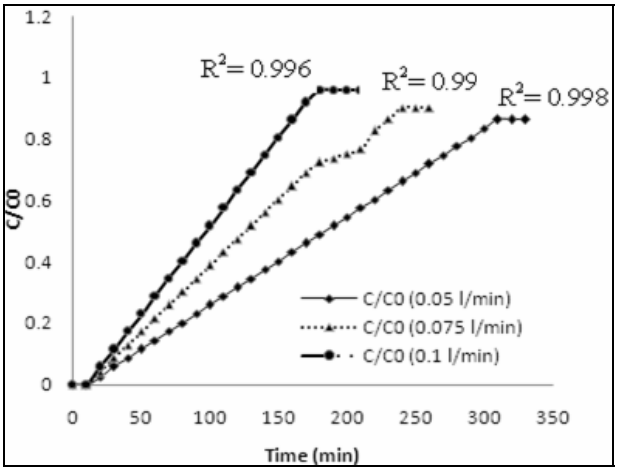


Fig. 4: Break through curve on different flow rate (adsorbent = thermal power plant ash; Inlet concentration = 20%)

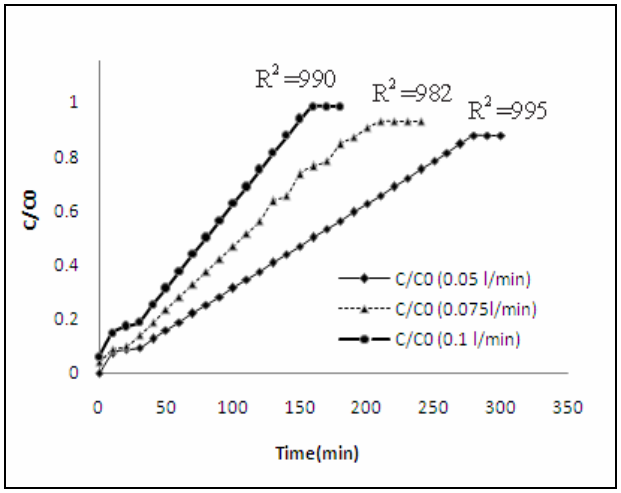


Fig. 5: Break through curve on different flow rate (adsorbent = bagasse fly ash)

Comparing both the adsorbent i.e. thermal power plant fly ash and sugarcane bagasse fly ash at different flow rate, the adsorption capacity of sugar cane bagasse is found greater than thermal power plant fly ash. The density of thermal power plant fly ash is five times greater than density of bagasse fly ash but the adsorption capacity is less because the surface area of thermal power plant fly ash is less in comparison. Adsorption capacity is also dependent upon the break through point, flow rate and weight of adsorbent. Finally the breakthrough adsorption capacity of thermal power plant fly ash and sugarcane bagasse fly ash at different three flow rates as shown in Table 1.

Table 1: Flow rate and adsorption capacity of thermal power plant fly ash and bagasse fly ash

Thermal power plant fly ash		Sugarcane bagasse fly ash	
Flow Rate	**Adsorption capacity**	**Flow Rate**	**Adsorption capacity**
50 mL/min	13.39 m mol/g	50 mL/min	22.32 m mol/g
75 mL/min	13.39 m mol/g	75 mL/min	33.48 m mol/g
100 mL/min	8.92 m mol/g	100 mL/min	44.64 m mol/g

If time is increased, the percentage of CO_2 adsoption is decreased. Fig. 5 and Fig. 6 shows that percentage of CO_2 adsorbed with respect to time at different three flow rate are as follows.

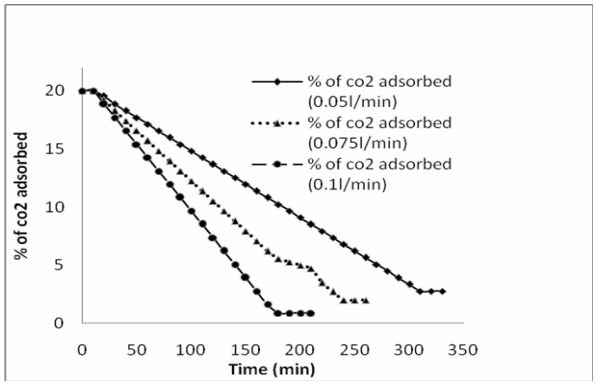


Fig. 6: % of CO_2 adsorbed at different flow rate (adsorbent = thermal power plant fly ash)

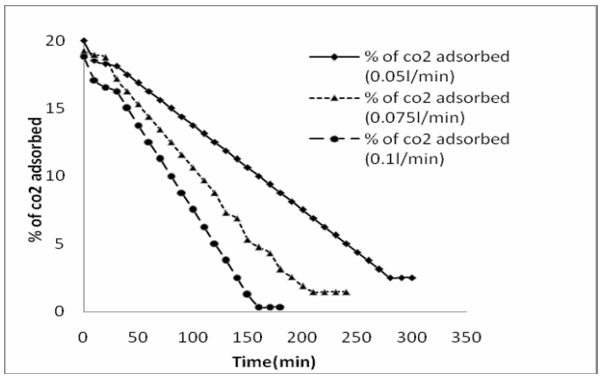


Fig. 7: % of CO_2 adsorbed at different flow rate (adsorbent = bagasse fly ash)

CONCLUSION

The adsorption of CO_2 using thermal power plan fly ash and bagasse fly ash as an adsorbent has been studied by using different flow rates. The breakthrough adsorption capacity was depends upon internal structure of adsorbent. Comparing both the adsorbents, it was found that bagasse fly ash was better adsorbent as compare to thermal power plant fly ash. From above experimentation, we were succeed to adsorb maximum 97.5% CO_2 by bagasse fly ash and 86.25% CO_2 by thermal power plant fly ash in a continuous adsorption experiment.

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